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JP 630060038 U JP 590091436 U JP 540035605 B
JP 460023521 B

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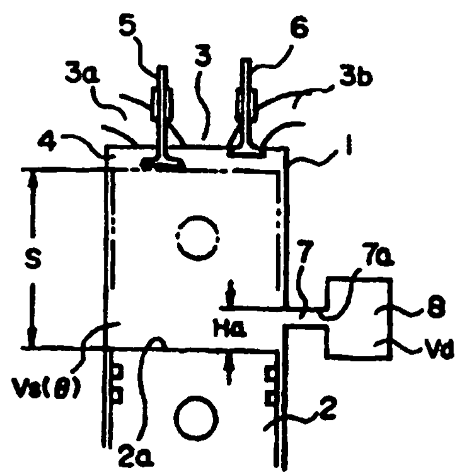
(54) Miller cycle engine

(57) A miller cycle engine which is simple in construction, and provides a low compression ratio and a high expansion ratio, thereby making it possible not only to improve the thermal efficiency and exhaust emissions of the engine but also to clean exhaust gas and prevent an increase in blow-bye amount. To this end, a volume chamber (8) communicating with a cylinder chamber (4) at a position a predetermined distance (Ha) above the bottom dead center of the stroke of a piston (2) is provided, and the volume chamber (8) refrains a pressure increase in the cylinder chamber (4) at the beginning of a compression stroke. In addition, a pressure piston ring (32) is disposed at the skirt portion of piston (10) for preventing fresh air and exhaust gas accumulating in said volume chamber (8) from leaking into a crank case (13).



GB 2 300 226 A

FIG. 1

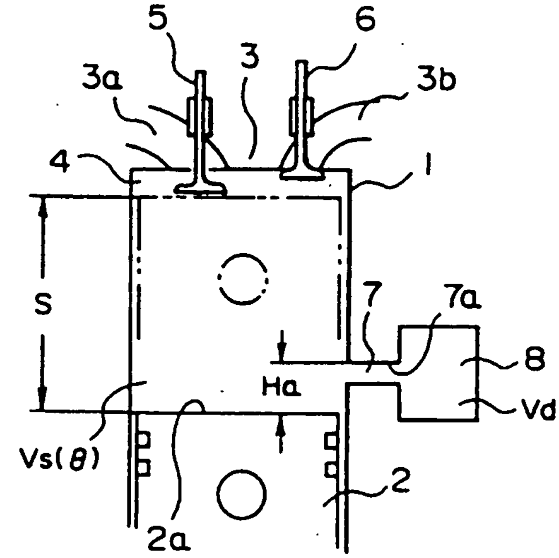

5
6
3
3a
3b
4
1
S
7
7a
8
Ha
Vd
Vs(θ)
2
2a

FIG. 2

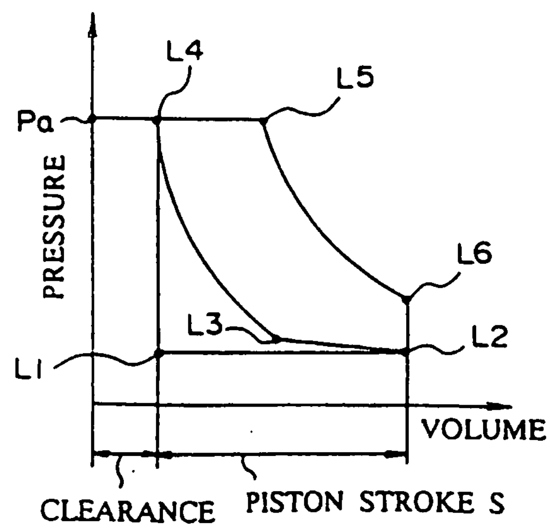

L4
L5
Pa
PRESSURE
L6
L3
L2
L1
VOLUME
CLEARANCE
PISTON STROKE S

FIG. 3

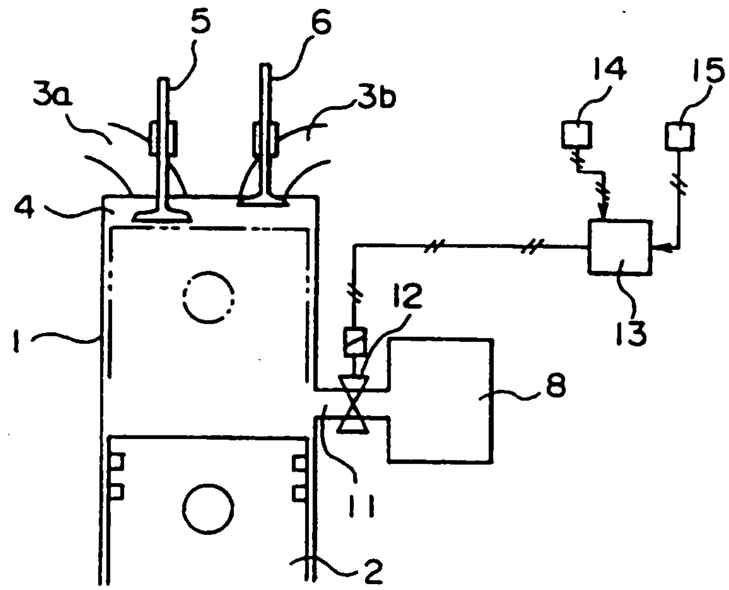

5
6
3a
3b
14
15
4
12
1
13
8
11
2

FIG. 4

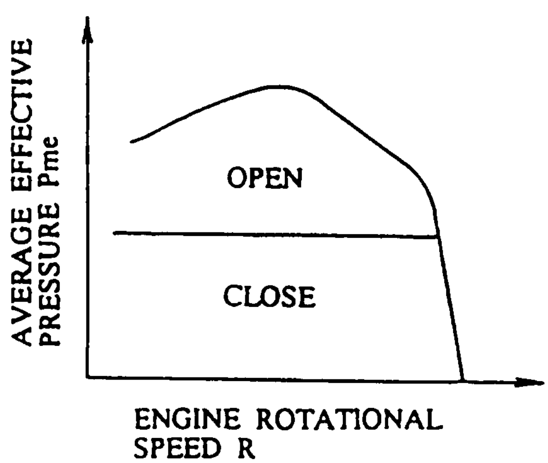
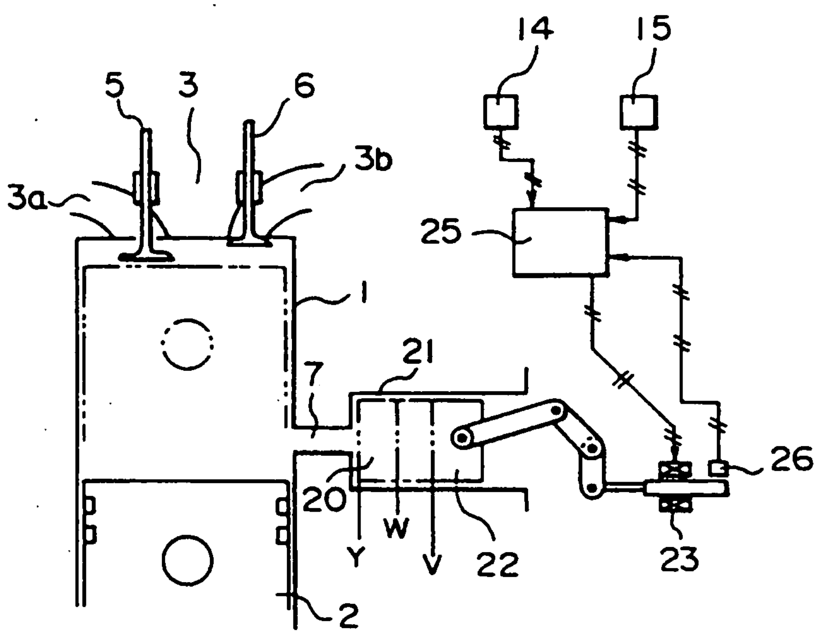
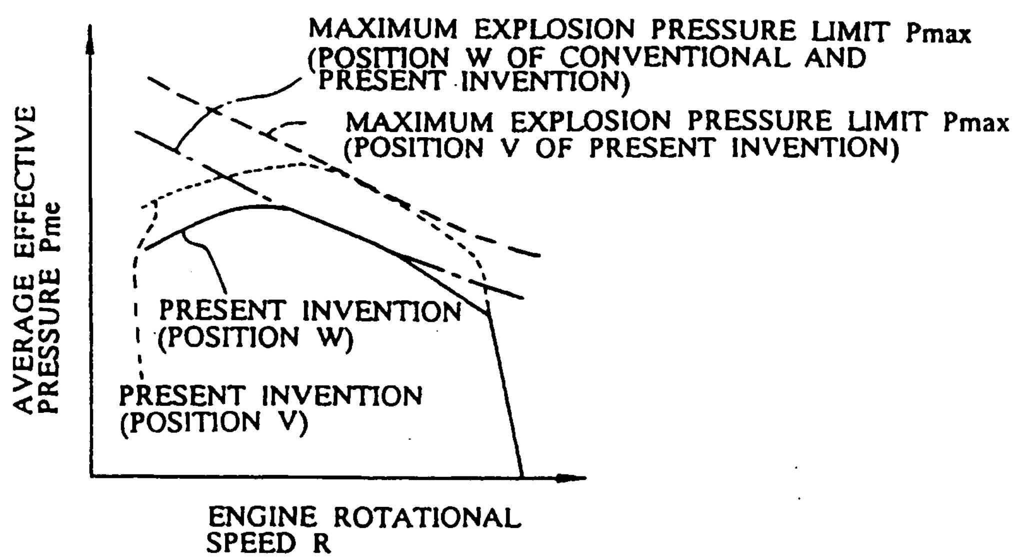

AVERAGE EFFECTIVE PRESSURE Pme
OPEN
CLOSE
ENGINE ROTATIONAL SPEED R

FIG. 5



14
15
5
3
6
3b
3a
25
1
21
7
26
20
W
Y
V
22
23
2

FIG. 6



MAXIMUM EXPLOSION PRESSURE LIMIT Pmax (POSITION W OF CONVENTIONAL AND PRESENT INVENTION)
MAXIMUM EXPLOSION PRESSURE LIMIT Pmax (POSITION V OF PRESENT INVENTION)
AVERAGE EFFECTIVE PRESSURE Pme
PRESENT INVENTION (POSITION W)
PRESENT INVENTION (POSITION V)
ENGINE ROTATIONAL SPEED R

FIG. 7

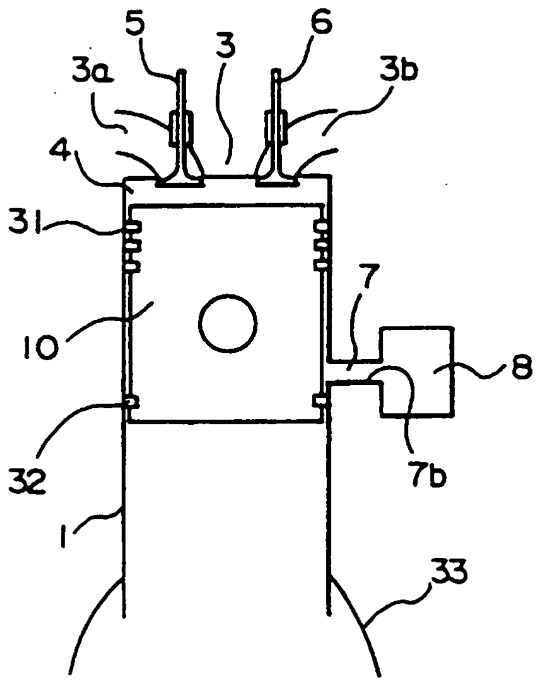


FIG. 8

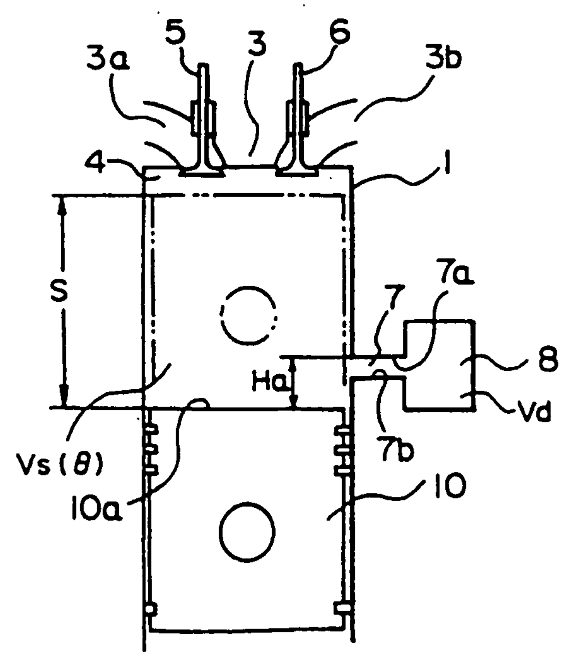


FIG. 9

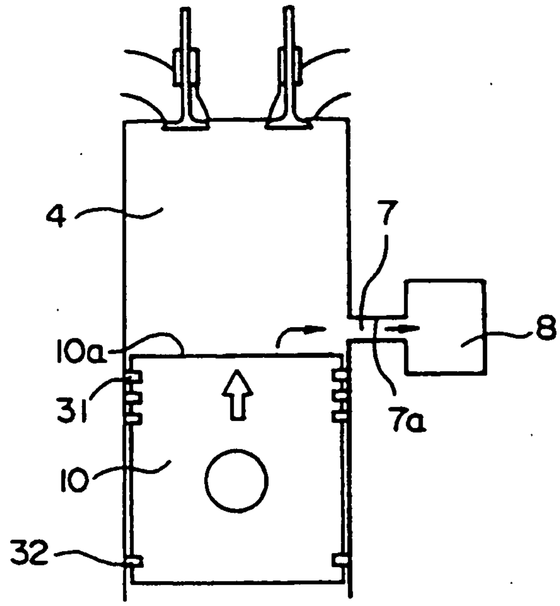


FIG. 10

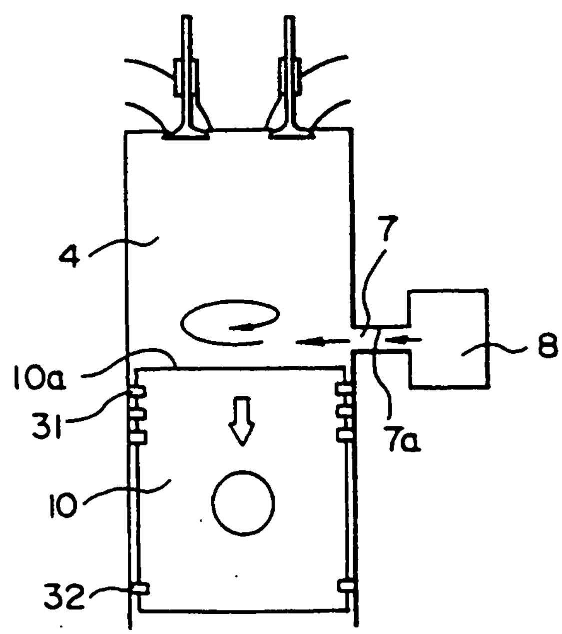


FIG. 11 CONVENTIONAL ART

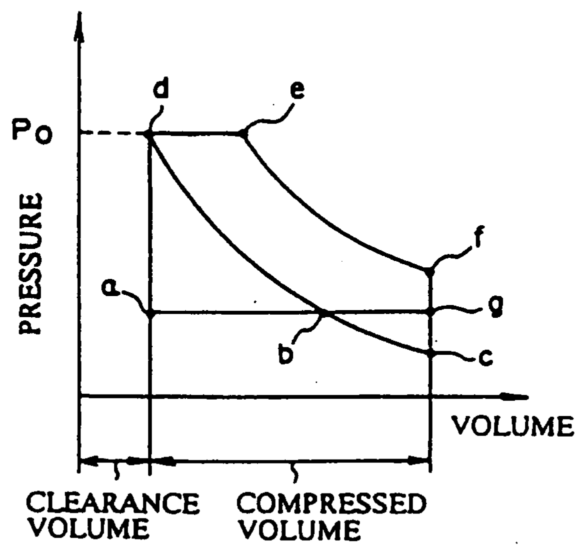
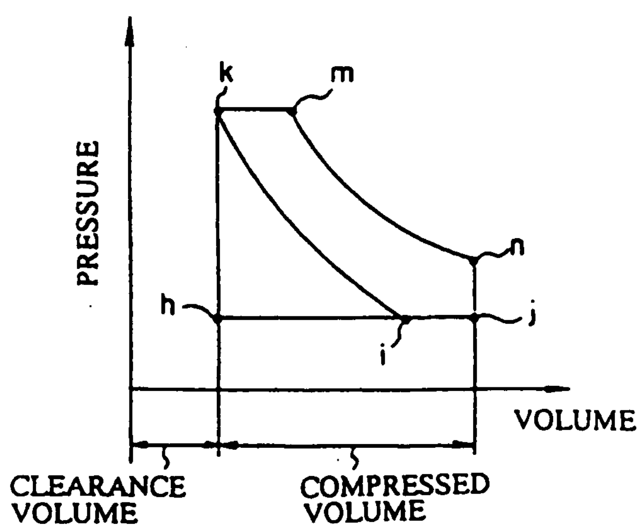


FIG. 12 CONVENTIONAL ART



SPECIFICATION

MILLER CYCLE ENGINE

Technical Field

The present invention relates to a Miller cycle engine, and more particularly to a Miller cycle engine provided with a volume chamber communicating with a cylinder chamber.

Background Art

Conventionally as for a Miller cycle engine a method of closing an admission valve early (refer to, for example, Japanese Patent Application Laid-open No. 55-148932 Official Gazette) and a method of closing an admission valve late (refer to, for example, Japanese Patent Application Laid-open No. 2-123244 Official Gazette) have been used. In the method of closing an admission valve early as illustrated in the pressure indication diagram of Fig. 11, in the period of an admission stroke (from a to b to c), a compression stroke (from c to b to d), an expansion stroke (from e to f) and an exhaust stroke (from g to b to a), an expansion is conducted at the latter half of the admission stroke (from b to c) by closing an admission valve early during an admission stroke.

In a method of closing an admission valve late, as shown in

Fig. 12, in the period of an admission stroke (from h to i to j), a compression stroke (from j to i to k), an expansion stroke (from m to n) and an exhaust stroke (from j to i to h), an admission pressure is let out at the beginning of the compression stroke (from j to i) by closing the admission valve late during the admission stroke. In this method of closing the admission valve late, a stroke without compression is provided by keeping the admission valve open at the compression stroke, and the compression ratio is practically decreased by flowing part of the admitted air backward into an admission manifold as a piston is ascending. Further, in this method, it is known that air is sufficiently supplied in the cylinder chamber by using a screw type of compressor at the admission part and that part of the air is flown backward into the admission manifold.

However, both aforementioned conventional Miller cycle engines, in which an admission valve is closed early or late by using a variable valve timing device, or an admission valve is closed early by using a rotary valve device, have disadvantages of complicated structures and of low durability.

Disclosure of the Invention

An object of the present invention, which is made for the purpose of eliminating the disadvantages of the conventional art, is to provide an economical Miller cycle engine having a simple structure in which only a volume chamber communicating with a

cylinder chamber is provided.

The characteristics of the Miller cycle engine relating to the present invention is that a volume chamber communicating with the cylinder chamber at the position a specified distance above the bottom dead center of the stroke of a piston is provided and that the volume chamber controls a pressure increase in the cylinder chamber at the beginning of a compression stroke. An opening and closing valve may be provided at a passage communicating with the cylinder chamber and the volume chamber. A controller connecting to this opening and closing valve may be provided to control the opening and closing of the opening and closing valve. The volume of the volume chamber may be a variable volume. This volume chamber may be provided with a variable mechanism such as a solenoid, piston, actuator, or the like, which changes the volume of the volume chamber. A controller connecting to this variable mechanism may be provided to control the volume of the volume chamber. Further an engine rotation sensor and a rack position of an engine fuel injection pump detecting sensor which connects to the controller may be provided and the engine rotational speed and the rack position which are measured may be inputted in the controller. In the aforementioned structure, a pressure piston ring may be positioned at a skirt portion of the piston, and this pressure piston ring may prevent fresh air accumulating in the volume chamber at the beginning of the compression stroke and exhaust gas accumulating in the volume chamber at the beginning of the exhaust stroke from leaking into a crankcase.

By this structure, which is provided with the volume chamber communicating with the cylinder chamber, a pressure increase in the cylinder chamber is reduced to be a low level by using the volume of the volume chamber at the beginning of the compression stroke. When the piston ascends as far as the distance of a specified stroke, the piston blocks the hole of the cylinder chamber communicating with the volume chamber, so that the pressure in the cylinder chamber increases as much as a specified value. Accordingly, since the volume chamber controls pressure increase, the specified value can have a low value and the compression ratio is practically low. Accordingly with a simple structure, all the air admitted in the cylinder chamber can be used, therefore the engine can produce the output of a low compression ratio and high expansion ratio corresponding to the volume of the cylinder and the thermal efficiency of the engine can be improved. By a variable volume chamber, the control of a Miller cycle according to a rotational speed of the engine is possible and higher output can be produced.

Since the pressure piston ring is provided at the skirt portion of the piston, fresh air accumulating in the volume chamber at the beginning of the compression stroke does not leak into the crankcase, a sufficient amount of air jets into the cylinder chamber at the latter period of the expansion stroke and stirs combustion gas to promote oxidation. Accordingly the exhaust gas is cleaned and air and exhaust gas do not leak into the crank case, so that an increase

in the blow-bye amount can be prevented.

Brief Description of Drawings

Fig. 1 is a general view of the essential parts of the Miller cycle engine in the first embodiment of the present invention;

Fig. 2 is a pressure indication diagram of the four-cycle diesel engine of the Miller cycle engine of the present invention;

Fig. 3 is a general view of the essential parts of the Miller cycle engine in the second embodiment of the present invention;

Fig. 4 is a graph showing the relationship between the engine rotational speed R and the average effective pressure Pme in the second embodiment;

Fig. 5 is a general view of the essential parts of the Miller cycle engine in the third embodiment of the present invention;

Fig. 6 is a graph showing the relationship among the engine rotational speed R (rpm), the average effective pressure Pme and the maximum explosion pressure limit Pmax in the third embodiment;

Fig. 7 is a general view of the essential parts of the position of the top dead center of the stroke of the piston of the Miller cycle engine in the fourth embodiment of the present invention;

Fig. 8 is a general view of the essential parts of the position of the bottom dead center of the stroke of the piston of the Miller cycle engine in the fourth embodiment of the present invention;

Fig. 9 is a general view of the state at the beginning of the

compression stroke in the fourth embodiment;

Fig. 10 is a general view of the state at the last period of the expansion stroke in the fourth embodiment;

Fig. 11 is a pressure indication diagram of the four cycle diesel engine with an admission valve closing early of the Miller cycle engine in the conventional art; and

Fig. 12 is a pressure indication diagram of the four cycle diesel engine with an admission valve closing late of the Miller cycle engine in the conventional art.

Best Mode for Carrying out the invention

A preferable embodiment of the Miller cycle engine of the present invention will be described below with reference to the attached drawings. Fig. 1 is a general view of a part of an engine depicting the first embodiment of the Miller cycle engine of the present invention. In Fig. 1, a piston 2 is closely inserted into a cylinder liner 1 and slides up and down as far as the distance of a specified stroke S. An engine head 3 is positioned at the upper end of the cylinder liner 1, and a cylinder chamber 4 is formed by the piston 2 and the engine head 3. At the engine head 3, an admission pipe 3a and an exhaust pipe 3b are provided, and a mushroom-shaped admission valve 5 is positioned at a communication port of the admission pipe 3a with the cylinder chamber 4, while a mushroom-shaped exhaust valve 6 is positioned at a communication port of the

exhaust pipe 3b with the cylinder chamber 4. A communication hole 7 is formed at a specified position, that is, a position a specified distance above the bottom dead center of a specified stroke S of the piston 2, and a specified volume chamber 8 is positioned at the communication hole 7.

The operation in the above-described structure will be described with reference to Fig. 2 depicting a pressure indicator diagram of the four-cycle diesel engine of the present invention. Fig. 2 depicts an admission stroke (from L1 to L2), a compression stroke (from L2 to L3 to L4), an expansion stroke (from L5 to L6), and an exhaust stroke (from L2 to L1). In the compression stroke, an admission valve 5 is closed and at the beginning of the compression stroke (from L2 to L3), a pressure increase is controlled to be a low level by using the volume of the volume chamber 8.

As Fig. 1 depicts, when a stroke volume of the cylinder chamber 4 which is changed by a rotational angle θ of the crank shaft (variation of the stroke S) is Vs (θ) and the volume of the volume chamber 8 is Vd, the cylinder stroke volume V is the sum of the stroke volume Vs (θ) and the volume Vd of the volume chamber 8 at the beginning of the compression stroke (distance Ha) which is from the beginning of the compression to the time when the top surface 2a of the piston 2 comes to the position blocking the top surface 7a of the communication hole 7. Then, at the compression stroke in which the piston further ascends (hereinafter called the latter half of the compression stroke) after the top surface 2a of the piston 2 blocked the top surface 7a of the communication hole 7, the cylinder stroke volume V is only the same as

the stroke volume Vs (θ) of the cylinder chamber 4.

Accordingly, when the product of a pressure P of the cylinder chamber 4 and the cylinder stroke volume V in the compression stroke is fixed, the cylinder stroke volume V (= Vs (θ) + Vd) is large at the beginning of the compression stroke, therefore the rate of change of the pressure P can be decreased compared to the rate of change of the cylinder stroke volume V. Accordingly, a pressure increase can be controlled to be a low level (from L2 to L3). Meanwhile, at the latter half of the compression stroke, the cylinder stroke volume V (=Vs (θ)) is small, so that the rate of change of the pressure P can be increased compared to the rate of change of the cylinder stroke volume V. Accordingly the pressure increase is large (from L3 to L4) and sufficient compression pressure Pa can be obtained. In such a stroke, it is not necessary to let the air admitted into the cylinder chamber 4 escape into the admission part or expand the air admitted into the cylinder chamber 4 by closing the admission valve 5 early. Accordingly the fresh air accumulated in the volume chamber 8 at the beginning of the compression stroke jets out of the volume chamber 8 into the cylinder chamber 4 at the late period of the expansion stroke and stirs combustion gas, so that the oxidation of the combustion gas is promoted and the exhaust gas is cleaned. The aforementioned compression pressure Pa of the present invention is a low pressure as in the conventional compression pressure Po shown in Fig. 11, so that the compression ratio can be low.

As described above, in the present invention, a low compression

ratio and a high expansion ratio can be obtained, so that the thermal efficiency and exhaust emissions of an engine can be improved.

Next, the second embodiment relating to the Miller cycle engine of the present invention is described with reference to the drawings. It is mentioned that the description of the same parts as in the first embodiment is abbreviated by affixing the identical marks.

Fig. 3 depicts an essential part of the engine of the present embodiment, and an electro-magnetic valve 12 (an opening and closing valve) which opens and closes is positioned at a passage 11 which communicates the cylinder chamber 4 and the volume chamber 8. This electro-magnetic valve 12 is connected to a controller 13. An engine rotation sensor 14 which is attached to the crankshaft and so on (not illustrated in the drawings) and which measures the rotational speed of the engine, and a rack position detecting sensor 15 detecting the position of the rack of an injection pump injecting fuel into the cylinder chamber 4 are connected to the controller 13.

The operation in the aforementioned arrangement will be described with reference to Fig. 3 and the relationship between an engine rotational speed R (rpm) and an average effective pressure Pme shown in Fig. 4. The position of the rack of the fuel injection pump is set by the command from the accelerator pedal and so on which is not illustrated in the drawings, and this position of the rack is detected by the rack position detecting sensor 15. The rotational speed of the engine is measured by the engine rotation sensor 14.

The signals from the aforementioned rack position detecting sensor 15 and the engine rotation sensor 14 are sent to the controller 13, and the controller 13 performs the computation of the average effective pressure Pme from both signals. When the computed average effective pressure Pme is a specified amount or less, the command signal for closing the electro-magnetic valve 12 is outputted. By this, when the engine load is light, a engine drives normally, and when the engine load is heavy, the engine becomes a Miller cycle engine, so that a low compression ratio and high expansion ratio are obtained and the thermal efficiency of the engine can be improved.

Next, the third embodiment relating to the Miller cycle engine of the present invention is described with reference to the drawings. It is mentioned that the description of the same parts as in the aforementioned embodiment is abbreviated by affixing the identical marks.

Fig. 5 is an essential part of the engine of the present embodiment, and a volume chamber 20 of which volume is variable is positioned at the communication hole 7 formed at a specified position of the cylinder liner 1. This volume chamber 20 is defined by a cylinder 21, a piston 22 closely inserted into the cylinder 21, and a solenoid 23 moving the piston 22. The engine rotation sensor 14 measuring the rotational speed of the engine and the rack position detecting sensor 15 detecting the position of the rack of the aforementioned injection pump are connected to the a controller 25 connecting to the solenoid 23.

The operation in the aforementioned structure will be described with reference to Fig. 5 and Fig. 6. When an engine is supercharged by a turbo-charger or a supercharger in order to make a high-power engine, the maximum explosion pressure limit Pmax of the conventional Miller cycle engine is limited to the output shown by a dashed line in the drawing. In this embodiment, when the output limit corresponds to Pmax on this dashed line, if, for example, the piston 22 is at an intermediate position W having a specified volume, the average effective pressure Pme is a curved solid line. Further when the engine obtains a low compression ratio and high expansion ratio and the thermal efficiency of the engine is needed to be improved, the piston 22 is withdrawn to a position V having a specified larger volume in Fig. 5. By this, Pme which can be outputted by the same Pmax, can rise to the position of the curved dotted line.

The case in which the output of the engine is changed by withdrawing the piston 22 is described above, and the engine is also used as an ordinary engine by advancing the piston 22 to the forefront until the piston is at the position in which the volume chamber 20 having a variable volume has a volume of zero, that is, at the position Y in Fig. 5. The method of this control is the same as in the second embodiment, and the position of the rack of the fuel injection pump and the rotational speed of the engine are sent to a controller 25 which performs a computation of the average effective pressure Pme from both signals. When the computed average effective pressure

Pme is a specified value or less, the piston 22 is advanced to the forefront and the volume of the volume chamber 20 is made to be zero. By this, when the engine load is light, an ordinary engine drives, and when the engine load is heavy, the engine becomes a Miller cycle engine by withdrawing the piston 22, so that a low compression ratio and high expansion ratio are obtained and the thermal efficiency of the engine can be improved. As described above, a Miller cycle engine with a simple structure can be provided.

In the aforementioned embodiment, the control of the opening and closing valve 12 and the volume chamber 20 with a variable volume is conducted by using an electro-magnetic solenoid, however, a variable mechanism which controls an actuator, a control valve and so on by oil pressure, air pressure and so on may be used.

Next, the fourth embodiment relating to the Miller cycle engine of the present invention is described with reference to the drawings. It is mentioned that the description of the same parts as in the aforementioned embodiment is abbreviated by affixing the identical marks.

Fig. 7 depicts a state in which the piston of the Miller cycle engine of the present embodiment is positioned at the top dead center of the stroke of the piston, and in the cylinder liner 1 integrated with a crankcase 33, the piston 10 is closely inserted. At the upper portion of this piston 10, pressure piston rings 31 are attached, and at the skirt portion, pressure piston rings 32 are attached. When the piston 10 is at the top dead center, the pressure piston rings 32

at the skirt portion are positioned at the place lower than the bottom surface 7b of the communication hole 7.

Fig. 8 depicts the state in which the piston 10 is positioned at the bottom dead center of the stroke of the piston, and the piston 10 slides up and down as far as a specified stroke S by the rotation of the crankshaft which is not illustrated in the drawing. When the piston 10 is at the bottom dead center, the top surface 10a of the piston 10 is positioned at a place lower than the bottom surface 7b of the communication hole 7 and the distance from the top surface 10a to a top surface 7a is the distance Ha.

The description of the pressure indication diagram regarding the four-cycle diesel engine in this structure is abbreviated since the diagram is basically the same as the pressure indication diagram of the first embodiment (Fig. 2). Then the operation of the piston ring 32 which is not in the first embodiment. As Fig. 9 depicts, at the beginning of the compression stroke of the piston 10, fresh air admitted in the cylinder chamber 4 is accumulated in the volume chamber 8 as the arrow of the solid line shows until the top surface 10a of the piston 10 ascends from the bottom dead center and passes the top surface 7a of the communication hole 7.

Then the piston 10 ascends to conduct compression, then fuel burns and expansion begins, and at the latter stage of the expansion stroke when the top surface 10a of the piston 10 passes the top surface 7a of the communication hole 7, the fresh air confined in the volume chamber 8 jets into the cylinder chamber 4 as the arrow

shows, stirs the combustion gas to promote the oxidation and cleans the exhaust gas. During this period, the volume chamber 8 is shut from the crank-case 33 by the pressure piston ring 32 as Fig. 7 depicts, so that the fresh air of the volume chamber 8 does not leak out. Accordingly at the latter stage of the exhaust stroke, a sufficient amount of fresh air jets into the cylinder chamber 4. The aforementioned fresh air and the exhaust accumulating in the volume chamber 8 at the beginning of the exhaust stroke do not leak into the crank-case 33, therefore a Miller cycle engine which can prevent an increase of the blow-bye amount can be provided.

Industrial Availability

The present invention, which is simple in structure in which the volume chamber communicating with the cylinder chamber is provided, is useful as a Miller cycle engine which provides a low compression ratio and high expansion ratio and can improve the thermal efficiency and exhaust emissions, and is also useful as a Miller cycle engine which can clean exhaust gas and prevent an increase of the blow-bye amount.

CLAIMS:

1. A Miller cycle engine which is provided with a piston and a cylinder chamber contacting said piston and which is made by controlling an increase of the pressure in said cylinder chamber, comprising:

a volume chamber which communicates with said cylinder chamber at a position a specified distance above a bottom dead center of a stroke of said piston and which controls the pressure increase in said cylinder chamber at the beginning of a compression stroke.

2. A Miller cycle engine according to Claim 1, wherein an opening and closing valve is provided at a passage communicating with said cylinder chamber and said volume chamber.

3. A Miller cycle engine according to Claim 2, wherein a controller connecting to said opening and closing valve is provided and said controller controls the opening and closing of said opening and closing valve.

4. A Miller cycle engine according to Claim 1, wherein a volume of said volume chamber is a variable volume.

5. A Miller cycle engine according to Claim 4, wherein said volume chamber is provided with a variable mechanism such as a

solenoid, a piston, an actuator, or the like and said variable mechanism changes the volume of said volume chamber.

6. A Miller cycle engine according to Claim 5, wherein a controller connected to said variable mechanism is provided and said controller controls the volume of said volume chamber.

7. A Miller cycle engine according to Claim 3 or Claim 6, wherein an engine rotation sensor connected to said controller and a rack position detecting sensor of an engine fuel injection pump are provided and the rotational speed of the engine and the position of a rack which are measured are inputted in said controller.

8. A Miller cycle engine according to any one of Claim 1 to Claim 7, wherein a pressure piston ring is provided at a skirt portion of said piston and said pressure piston ring prevents air accumulating in said volume chamber at the beginning of aforementioned compression stroke and exhaust gas accumulating in said volume chamber at the beginning of an exhaust stroke from leaking into a crankcase.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP94/02215

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 F02B21/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^6 F02B21/00-23/10,19/00-19/18, F02D15/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1926 - 1994
Kokai Jitsuyo Shinan Koho 1971 - 1994

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, B2, 54-35605 (Mitsubishi Heavy Industries, Ltd.), November 5, 1979 (05. 11. 79) Lines 1 to 12, column 4, Fig. 2 (Family: none)	1-8
Y	JP, B1, 46-23521 (Mitsubishi Heavy Industries, Ltd.), July 6, 1971 (06. 07. 71), Lines 4 to 8, column 3, Fig. 1 (Family: none)	1-8
Y	JP, U, 63-60038 (Kawasaki Heavy Industries, Ltd.), April 21, 1988 (21. 04. 88), Fig. 1 (Family: none)	2,3
Y	JP, U, 59-91436 (Honda Motor Co., Ltd.), June 21, 1984 (21. 06. 84), (Family: none)	4-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
March 8, 1995 (08. 03. 95)	April 4, 1995 (04. 04. 95)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.